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AUTHOR Peterson, John C.; Hancock, Robert R.
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ABSTRACT

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DEVELOPING MATHEMATICAL MATERIALS FOR APTITUDE-TREATMENT INTERACTION

John C. Peterson and Robert R. Hancock

Eastern Illinois University

Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, Illinois, April 19, 1974

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Introduction

This report describes a continuation of efforts to design mathematical lessons in network tracing geared to specified cognitive aptitudes of students and to use those lessons to study aptitude-treatment interactions.

The topics of cognitive style and aptitude-treatment interaction (ATI) have recently interested many educational psychologists and educational researchers. In 1957, Cronbach stated that:

> Ultimately we should design treatments, not to fit the average person, but to fit groups of students with particular aptitude patterns. Conversely, we should seek out the aptitudes which correspond to (interact with) modifiable aspects of the treatment.

Later Gagné (1960) suggested that the addition of directed numbers might be taught experimentally by three modes designed to employ a spatial, numerical, or verbal mode of presentation, respectively. He conjectured that Ss who score higher on a test of spatial ability than on a test of verbal or numerical ability will learn a concept more readily via spatially oriented materials than when verbally or symbolically oriented materials and that Ss who score relatively higher in numerical ability will learn a concept more readily using symbolically oriented instruction than by using spatially or verbally oriented instruction.

Cronbach (1967) indicated that in order for instruction to be adapted for individual differences three conditions must be met:

1. There must be different instructional methods.
2. The instructional methods must teach to the same criterion or objective.
3. There must exist one or more aptitude measures for which regressions of criterion scores upon the aptitudes exhibit a disordinal interaction.

Many studies of cognitive style of learning and ATI have been conducted (for example: Behr, 1970; Bracht, 1970; Bracht and Glass, 1970; Berliner, 1971 and 1972; Carry, 1968; Davis, J. B., 1968; Davis, J. K., 1972 and 1973; Scott, 1972; Webb, 1971 and 1972; Hancock, 1972 and 1973; Nelson, 1973; Montgomery, 1973; and Eastman, 1972). The majority of these studies were unsuccessful in their attempts to find meaningful disordinal interactions. It is interesting to note that the study of Eastman (1972) was a follow-up of Webb's (1971) study which in turn was a follow-up of Carry's (1968) study. Eastman was successful in modifying the other two studies enough to find a significant aptitude-treatment interaction.

"In many studies, the alternative treatment was only some minor modification of some original instructional program. Experimenters need to move beyond this level and develop alternative treatments from a conception of the abilities which are relevant to successful performance in the alternative treatments." (Bracht, 1970, p. 639) Thus, before a significant study of ATI can be undertaken, alternative treatments that conform to the personological variables under consideration need to be

developed. Peterson and Hancock (1973) described a method to determine if these alternative treatments have been developed. This paper reports on continued efforts to construct alternative treatments that conform to certain personological variables and an ATI study using these treatments.

Personological Variables

The personological variables investigated in this study were selected from among the mental factors identified in Guilford's Structure-of-Intellect (SI) model. (Guilford, 1967) Guilford's SI model is a three-way classification of intellectual abilities designed to organize intellectual-aptitude factors according to the operation, content, and product of a given kind of intellectual act. According to Guilford's model there exist 120 mental factors. It was necessary to select a subset of these 120 mental factors that would be small enough to allow for the construction of a battery of tests that could be administered in a reasonable length of time.

Along the operation dimension only the category of cognition (C) was selected for investigation. Cognition is "immediate discovery, awareness, rediscovery, or recognition of information in various forms; comprehension or understanding." (Guilford and Hoepfner, 1966) The operations categories of memory, divergent production, convergent production, and evaluation were not regarded as any less important, but rather as being less relevant at this stage of the research.

The selection of the figural (F), semantic (M), and symbolic (S) categories along the content dimension was closely related to the choice of modes of presentation for the respective instructional programs. Figural content is "information in concrete form, as perceived or as recalled possibly in the form of images . . . Visual spatial information is figural." Symbolic content is "information in the form of denotative

signs, having no significance in and of themselves, such as letters, numbers . . ." Semantic content is "information in the form of meanings to which words commonly become attached, hence most notable in verbal thinking and in verbal communication but not identical with words . . ." (Guilford and Hoepfner, 1966)

Along the products dimension it was decided to select the categories of units (U), classes (C), and relations (R). To have included others would have necessitated the construction of a battery of tests that would have required an excessive amount of time to administer. Guilford and Hoepfner define units as "relatively segregated or circumscribed items of information having 'thing' character." Classes are defined as "conceptions underlying sets of items of information grouped by virtue of their common properties." Relations are defined to be "connections between items of information based upon variables or points of contact that apply to them."

Hence, the mental factors chosen for investigation in this study represents a 3 x 3 x 1 corner of the SI model. The mental factors, their trigram representation, the name of the test used to measure each mental factor, the reliability of the test reported by the publisher, and a brief description of the test is given in Table 1. Tests designed to measure SI abilities were developed in conjunction with the Aptitude Research Project at the University of Southern California. Tests were arranged into a two-part battery on the basis of commonality of scoring methods.

Insert Table 1 about here

Subjects

The subjects were undergraduate students enrolled in Mathematics 125 or Mathematics 126 at Eastern Illinois University during the Spring Quarter, 1973. Both courses were cultural level courses which met for four periods of fifty minutes each per week. Neither course can be taken by a student with a major or a minor in mathematics. Mathematical background of students taking these courses is usually minimal and, ordinarily, the present course was the terminal mathematics course for the students involved.

Instructional Materials

The instructional materials explained the mathematical concept of network tracing. This concept was selected because (1) it was a topic that could be learned in less than thirty-five minutes (this would leave at least ten minutes for students to complete the learning test), (2) it was a topic that was probably unfamiliar to the Ss, and (3) the Es' previous experience indicated that this was a topic that would lend itself to instruction from the figural, verbal, and symbolic modes.

Instructional materials on network tracing which the Es' believed were figurally oriented, verbally oriented, or symbolically oriented had previously been constructed. A previous study (Peterson and Hancock, 1973) tended to confirm that (1) the figural lesson was figurally oriented and not verbally or symbolically oriented; (2) the verbal lesson was verbally oriented (and, to some extent, symbolically oriented) and not figurally oriented; and (3) the symbolic lesson was only slightly symbolically oriented and also had a definite figural orientation.

It was felt that all of these lessons needed some revision — particularly the verbal and the symbolic lessons. Furthermore it was felt that

the criterion tests needed to be revised in two ways. (1) Items had to be included in the tests that were written using the symbolic notation in the symbolic lesson. (2) A fifth response needed to be provided on the multiple-choice items of the exam. Analysis of the original tests indicated that some Ss had marked the fifth response on the machine scored answer sheet as correct even though only four responses were given to the item. Two possibilities existed: (a) Ss were guessing at the correct answer and had randomly marked response five or (b) Ss thought that the last (fourth) response was the correct answer and marked the last (fifth) response blank on the answer sheet. Adding a fifth response to each of the multiple choice items should have prevented the latter from being a factor on the revised tests.

Following the above revision guidelines, three similar 20-item tests were constructed — one to measure immediate learning, one to measure retention one week after instruction, and one to measure retention four weeks after instruction. The first sixteen items on each test were multiple choice items. The first ten items of each test measured whether Ss could determine whether a vertex in a given network was even or odd, the next six items measured whether Ss could determine whether or not a given network was traceable. On the last four items, Ss were shown a network, told that it was not traceable, and asked to draw one segment which would make the network traceable.

The content validity of the tests was judged to be satisfactory by a panel of mathematics educators. The reliability coefficients for the learning test and the two retention tests as determined by the Kuder-Richardson Formula No. 20 were .88, .89, and .90, respectively for the total Ss. Correlation coefficients between each pair of tests was computed using Pearson product-moment correlation coefficient in an attempt

to measure the similarity of the tests. All correlations were .77 or higher. All correlations were significantly greater than zero.

Procedures

The last class meeting before the experiment was begun Ss were informed that they were to be a part of an experiment, that the next three class meetings and part of two subsequent class meetings would be devoted to this experiment and that the results of the experiment would not affect their grade for the course. Ss were asked to give their cooperation.

The next two class periods the personological tests were administered and the following class period Ss studied the instructional material and took the Learning Test. The instructional materials were arranged so that every third lesson was in the same instructional mode. This, and the fact that seats were unassigned, assured a random distribution of instructional lessons. Ss were given the entire class period (50 minutes) to read the instructional material and to complete the test. Exactly one week later Retention Test I was administered, and exactly four weeks after instruction Retention Test II was administered. Ss were given 15 minutes to complete each of the retention tests.

Analysis of the Data

The mean and standard deviation of each of the twelve independent variables were computed and Ss were separated into either Group A or Group B for each variable. An S was placed in Group A if his score on the variable was above the mean score for that variable. t-tests were computed comparing the scores on each criterion test of Ss in Group A on each independent variable with Ss in Group B. Table 2 contains

the means and standard deviations for Ss who studied the figural, verbal, or symbolic lesson, respectively, on each of the twelve independent variables and on the three criterion tests.

Insert Table 2 here

Ss were assigned to either the A_i or the B_i group depending on whether or not their score on variable i was above or below the variable mean. A t-test was then used to test the hypothesis. With each lesson there were twelve hypotheses, each stating that $\bar{x}_{A_i} = \bar{x}_{B_i}$. A Biomed computer program BMDX70 was used to analyze the data (Dixon, 1970). In order to reduce the possibility of a Type II error and in view of the relatively small sample sizes, an α-level of .10 was selected.

Findings and Conclusions

Figural Lesson

Table 3 contains the means and standard deviations for Group A and Group B on the Learning Test for the Ss who studied the figural lesson and the t-scores for these groups. On the Learning Test only two of the hypotheses failed to be rejected ($p < .10$) — Cognition of Figural Units (CFU) and Cognition of Symbolic Units (CSU).

Insert Table 3 here

Table 4 contains the means and standard deviations for Group A and Group B on Retention Test I for the Ss who studied the figural lesson and the t-scores for these groups. On Retention Test I eight of the hypotheses

Insert Table 4 here

were rejected ($p < .10$) — Cognition of Figural Classes (CFC), Total Cognition of Figural Content (CF-T), Cognition of Semantic Units and Classes (CMU and CMC), Total Cognition of Semantic Content (CM-T), Cognition of Symbolic Classes and Relations (CSC and CSR) and Total Cognition of Symbolic Content (CS-T).

Table 5 contains the means and standard deviations for Group A and Group B on Retention Test II for the Ss who studied the figural lesson. t-scores for these groups, on Retention Test II nine of the

Insert Table 5 here

hypotheses were rejected ($p < .10$). The three hypotheses that failed to be rejected were Cognition of Figural Units and Relations (CFU and CFR) and Cognition of Symbolic Units (CSU).

If this lesson was a figural lesson and not a verbal or symbolic lesson then one would expect to reject the hypotheses for the CFU, CFC, CFR, and CF-T variables (i.e., Ss with high figural ability would score significantly higher on the criterion tests than Ss with low figural ability) and fail to reject the hypotheses for the remainder of the variables (i.e., high verbal or symbolic ability Ss would not score significantly higher on the criterion tests than Ss with low verbal or symbolic ability). On the three tests (Learning Test, Retention Test I, and Retention Test II) the findings were in the anticipated direction respectively on four, four, and three of the twelve variables. The results of this study do not support the hypothesis that the intended

figurally oriented materials are indeed figurally oriented.

These results are not consistent with the results of the earlier study (Peterson and Hancock, 1973). In that study the findings on each of the three tests were in the anticipated direction on ten of the twelve variables.

Verbal Lesson

Table 6 contains the means and standard deviations for Group A and Group B on the Learning Test for the Ss who studied the verbal lesson. Table 6 also contains the t-scores for these groups. On the Learning Test six of the hypotheses were rejected ($p < .10$) — Cognition of Semantic

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Insert Table 6 here

Units (CMU), Cognition of Semantic Classes (CMC), Cognition of Semantic Relations (CMR), Total Cognition of Semantic Content (CM-T), Cognition of Symbolic Units (CSU), and Total Cognition of Symbolic Content (CS-T). Notice that all four of the semantic variables were significant.

Table 7 contains the means and standard deviations for Group A and Group B on Retention Test I for the Ss who studied the verbal lesson and t-scores for these groups. On Retention Test I two of the semantic

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Insert Table 7 here

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variables failed to be significant ($p < .10$) — Cognition of Semantic Classes (CMC) and Cognition of Semantic Relation (CMR) while four of the figural or symbolic variables were significant.

Means and standard deviations and t-scores for Retention Test II of Ss that were in Group A or Group B on each of the twelve independent

variables are in Table 8. Two of the verbal independent variables were significant at the .10 level (CMC and CM-T) while none of the figural or symbolic variables were significant.

Insert Table 8 here

If this lesson was a verbal lesson and not a figural or symbolic lesson then one would expect to reject the hypotheses for the CMU, CMC, CMR, and CM-T variables and fail to reject the hypotheses for the remainder of the variables. On the Learning Test, Retention Test I, and Retention Test II, findings were in the anticipated direction on ten, six, and ten of the twelve variables, respectively. In the previous study (Peterson and Hancock, 1973), findings were in the anticipated direction on eight, five, and ten of the twelve variables, respectively. The results of this study tend to support the hypothesis that the intended verbally oriented materials are verbally oriented.

Symbolic Lesson

Tables 9, 10, and 11 contain the means and standard deviations for Group A and Group B on the Learning Test, Retention Test I, and Retention Test II, respectively, for the Ss who studied the symbolic lesson. Each table also contains the t-scores for these groups.

Insert Table 9 here

On the Learning Test all four of the symbolic variables were significant ($p < .10$). However, six of the figural or verbal variables were also significant.

On Retention Test I only two of the symbolic variables was significant ($p < .10$) -- Cognition of Symbolic Relations (CSR) and Total Cognition of

Symbolic Content (CS-T) and three of the eight figural or verbal variables

Insert Table 10 here

were significant.

On Retention Test II only two of the symbolic variables was significant at the .10 level -- Cognition of Symbolic Relations (CSR) and Total Cognition

Insert Table 11 here

of Symbolic Content (CS-T). Six of the figural or semantic variables were not significant.

If this lesson was a symbolic lesson and not a figural or verbal lesson then one would expect to reject the hypotheses for the CSU, CSC, CSR, and CS-T variables and fail to reject the hypotheses for the remainder of the variables. On the Learning Test, Retention Test I, and Retention Test II findings were in the anticipated direction on six, seven, and four of the twelve variables, respectively. In the previous study (Peterson and Hancock, 1973) findings were in the anticipated direction on seven, four, and six of the twelve variables, respectively. The results do not seem to support the hypothesis that the intended symbolically oriented lesson was symbolically oriented.

Aptitude-Treatment Interaction

The test for disordinal interactions was carried out by the regression analysis outlined below:

For each dependent variable, Y_i (i = 1,2,3), and for each independent variable, X_j (j = 1,2,...,12), simple linear regression equations were

determined for both of the treatment groups (F-M, F-S, or M-S) and if the regression lines intersected within the range of observed scores on the independent variable, X_j, then the difference between the regression coefficients was tested for significance. If this difference was found to be significant, then it was concluded that, with respect to the dependent variable, Y_i, a disordinal interaction existed between the independent variable, X_j, and the two treatment modes. A complete discussion of the statistics used to test the significance of the difference between the regression coefficients can be found in Dixon and Massey (1969, pp. 207-10). Results of the above analyses are given in Tables 12, 13, 14 for the comparisons of the Figural vs. Verbal, Figural vs. Symbolic, and Verbal vs. Symbolic treatments on the Learning Test (Table 12), Retention Test I (Table 13), and Retention Test II (Table 14).

Insert Table 12 here

Insert Table 13 here

Insert Table 14 here

As can be seen in Tables 12, 13, and 14 very few of the interactions were significant. It should be noted that the significance of a t-test indicates the occurrence of a disordinal interaction.

Discussion

Developing an understanding of concepts and principles related to ATI as a means of individualizing the instructional process has proven to be a

challenging problem. Researchers have been, for the most part, uniformly unsuccessful in locating meaningful ATI's, and even less successful in structuring learning situations in such a way as to induce significant interactions. Meaningful aptitude-treatment-interaction results from the interrelated effects of (1) personological aptitude variables associated with the learner, (2) instructional modes that are somehow intrinsically related to these variables, and (3) the desired outcomes of learning (i.e. immediate cognition, retention, transfer, etc.). However, the manner in which these factors may be related is by no means clear at this time.

In the present study the researchers attempted to develop instructional materials (presenting the mathematical concept of network tracing) that were related in meaningful ways to certain cognitive factors chosen from Guilford's SI model. The findings of this study provide further evidence attesting to the difficulty of this task. It was not possible to designate any of the instructional materials as being uniquely 'figural' (or 'verbal' or 'symbolic') in the sense of Guilford's model. The following remarks seem germane to this investigation.

It has been stated that before a significant study of ATI can be undertaken, alternative treatments that conform to the personological variables under consideration need to be developed. Thus, if verified alternative treatments are developed, then it was hypothesized that significant aptitude-treatment interaction would result. Since verified alternative treatments were not developed and significant ATI did not result, this investigation does not support the statement. But, this investigation does support the inverse of the statement, i.e. if verified alternative treatments are not developed, then significant aptitude-treatment interaction would not occur. This in itself is very gratifying since it would be difficult to make any progress if both the statement and its inverse

were true.

An inspection of the aptitude tests used in this study will reveal that the tests are of a rather global nature. This is as one would expect; however, it may be that cognitive factors which are related to mathematical learning may be more specific in nature. For example, the instrument which measures cognition of semantic relations (CMR) as a rather universal trait may not be a sufficiently sensitive indicator when the semantic relations in question deal with mathematically oriented content. Hence it seems tenable to hypothesize that personological/aptitude measures may need to be developed which will relate to the cognitive factors suggested by Guilford, but which will also reflect the nature of the mathematical content being studied.

It will also be noted that the tests developed by Guilford et. al. which were used in this study are characteristically inductive in nature. Thus, if instructional material is presented in a deductive manner, it may be that measures of independent variables should also be of a deductive nature. This facet of ATI research seems to warrant consideration in future studies.

Guilford's SI model is a frequently used source of personological/aptitude variables in ATI studies; however, productive investigations in this area may be awaiting the development of other measures of individual aptitude. These measures may need to be more specific in the sense of content (i.e. mathematical) orientation as well as the inductive/deductive nature of the instrument. This suggests a possible need for a whole new effort directed toward test development and validation.

It will be recalled that the independent variables in this study were selected from among the cognitive factors along the operations dimension of

the SI model. It may well be that other subcategories (i.e. memory, convergent production, etc.) along the operations dimension will prove to be more productive sources of ATI. The veracity of this conjecture awaits study by researchers interested in this problem.

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TABLE 1

DATA RELATIVE TO INDEPENDENT VARIABLES

Trigram	Independent Variable	Name of Test	Description of Test	Test Reliability
CFU	Cognition of Figural Units	Close-ups	Close-up photographs of portions of familiar objects were presented and subjects were asked to identify the objects	.66
CFC	Cognition of Figural Classes	Figure Classifications	Subject was to recognize classes of three sets of figures each, then assign given figures to the classes	.61
CFR	Cognition of Figural Relations	Figure Matrix	From multiple choices, subject was to select a figure to fill a matrix cell in a 3 x 3 matrix having different relations in columns and rows	.60
CF-T	Total Cognition of Figural Content		Total of scores on tests of figural factors	
CMU	Cognition of Semantic Units	Word Completion	S was asked to write a synonym or short definition for given word	.82
CMC	Cognition of Semantic Classes	Sentence Classification	S had to decide whether each given sentence conveyed a fact, possibility, or a name	.72
CMR	Cognition of Semantic Relations	Word Matrix Test	S was required to discover the relation in rows and columns, then to supply the missing word	.59
CM-T	Total Cognition of Semantic Content		Total of scores on tests of semantic factors	
CSU	Cognition of Symbolic Units	Omelet Test	Subject was to recognize a word whose letters have been scrambled	.68
CSC	Cognition of Symbolic Classes	Number-Group Naming	S was to state the property common to a group of three numbers	.67
CSR	Cognition of Symbolic Relations	Word Relations	A kind of analogies test in which the items of information related are words and the relations being in the form of spelling or alphabetical properties	.78
CS-T	Total Cognition of Symbolic Content		Total of scores on tests or symbolic facotrs	

TABLE 2

MEANS AND STANDARD DEVIATIONS FOR ALL Ss FOR EACH INDEPENDENT VARIABLE AND EACH CRITERION TEST

Trigram	Figural Lesson			Verbal Lesson			Symbolic Lesson			Total		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
CFU	57	11.77	3.72	52	10.88	3.85	61	10.74	3.18	170	11.13	3.58
CFC	57	11.61	3.98	52	10.29	3.94	61	11.74	3.49	170	11.25	3.83
CFR	57	12.54	3.39	52	12.88	3.49	61	12.74	2.97	170	12.72	3.26
CF-T	57	35.93	7.74	52	34.06	8.58	61	35.21	7.11	170	35.10	7.78
CMU	57	13.58	4.08	52	14.65	4.63	61	14.48	4.21	170	14.23	4.30
CMC	57	22.40	4.23	52	22.42	4.52	61	22.84	4.16	170	22.56	4.27
CMR	57	6.05	1.62	52	5.83	1.50	61	6.15	1.77	170	6.02	1.64
CM-T	57	42.04	7.75	52	42.90	8.42	61	43.46	7.91	170	42.81	7.99
CSC	57	16.51	5.05	52	17.06	5.03	61	17.00	4.69	170	16.85	4.90
CSU	57	6.89	2.14	52	7.58	2.26	61	7.21	2.64	170	7.22	2.37
CSR	57	9.56	3.65	52	9.59	3.73	61	9.67	3.81	170	9.61	3.71
CS-T	57	32.96	7.66	52	34.23	8.44	61	33.89	8.05	170	33.68	8.01
Learning Test	57	12.61	5.18	52	11.67	4.98	61	10.51	4.95	170	11.57	5.09
Retention Test I	51	13.02	5.22	48	12.08	4.85	54	11.56	5.27	153	12.21	5.13
Retention Test II	44	12.07	5.72	42	11.43	5.14	50	10.96	5.01	136	11.46	5.27

TABLE 3

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF FIGURAL LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE LEARNING TEST

Variable	Group B (Ss < $\bar{x}$)			Group A (Ss > $\bar{x}$)			t
	N	Mean	S.D.	N	Mean	S.D.	
CFU	23	12.261	5.154	34	12.853	5.269	.42
CFC	30	9.833	4.504	27	15.704	4.056	5.15*
CFR	26	11.346	5.396	31	13.677	4.833	1.72*
CF-T	27	9.852	4.793	30	15.100	4.221	4.40*
CMU	35	11.343	5.224	22	14.636	4.531	2.44*
CMC	28	10.393	4.856	29	14.759	4.619	3.48*
CMR	36	11.417	5.212	21	14.667	4.553	2.38*
CM-T	28	10.036	4.925	29	15.103	4.161	4.20*
CSU	29	12.310	5.439	28	12.929	4.988	.45
CSC	39	10.974	5.013	18	16.167	3.585	3.94*
CSR	30	11.400	4.818	27	13.963	5.331	1.91*
CS-T	32	11.594	5.002	25	13.920	5.220	1.71*

* $p < .10$

TABLE 4

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF FIGURAL LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE RETENTION TEST I

Independent Variable	Group B (Ss < $\bar{x}$) N	Mean	S.D.	Group A (Ss > $\bar{x}$) N	Mean	S.D.	t
CFU	21	12.381	5.287	30	13.467	5.218	.73
CFC	26	9.769	4.685	25	16.400	3.253	5.85*
CFR	23	11.826	5.306	28	14.000	5.033	1.50
CF-T	23	10.044	4.829	28	15.464	4.212	4.28*
CMU	32	11.531	5.285	19	15.526	4.128	2.82*
CMC	25	10.800	5.074	26	15.154	4.487	3.25*
CMR	32	12.344	5.283	19	14.158	5.047	1.21
CM-T	25	11.080	5.204	26	14.885	4.599	2.77*
CSU	27	12.482	5.713	24	13.625	4.651	.78
CSC	34	11.676	5.074	17	15.706	4.538	2.77*
CSR	25	11.520	5.042	26	11.462	5.069	2.08*
CS-T	27	11.815	5.255	24	14.375	4.942	1.79*

* $p < .10$

TABLE 5

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF FIGURAL LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE RETENTION TEST II

Independent Variable	Group B (Ss < $\bar{x}$)			Group A (Ss > $\bar{x}$)			t
	N	Mean	S.D.	N	Mean	S.D.	
CFU	16	10.938	5.105	28	12.714	6.036	.99
CFC	24	9.000	4.663	20	15.750	4.614	4.79*
CFR	20	11.200	5.818	24	12.792	5.657	.92
CF-T	19	9.210	4.626	25	14.240	5.585	3.18*
CMU	27	10.296	5.239	17	14.882	5.442	2.79*
CMC	25	10.360	5.073	19	14.316	5.869	2.39*
CMR	32	10.938	5.530	12	15.083	5.299	2.24*
CM-T	25	10.080	5.338	19	14.684	5.239	2.86*
CSU	23	12.435	5.876	21	11.667	5.660	-.44
CSC	28	10.714	5.583	16	14.438	5.316	2.16*
CSR	24	10.208	5.030	20	14.300	5.814	2.50*
CS-T	26	10.885	5.309	18	13.778	6.005	1.68

* $p < .10$

TABLE 6

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF VERBAL LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE LEARNING TEST

Independent Variable	Group B (Ss < $\bar{x}$)			Group A (Ss > $\bar{x}$)			t
	N	Mean	S.D.	N	Mean	S.D.	
CFU	27	10.852	5.119	25	12.560	4.770	1.24
CFC	28	10.964	5.453	24	12.500	4.344	1.11
CFR	22	10.409	5.492	30	12.600	4.438	1.59
CF-T	28	10.750	4.727	24	12.750	5.152	1.46
CMU	25	10.040	5.160	27	13.185	4.377	2.38*
CMC	23	9.739	5.029	29	13.207	4.451	2.63*
CMR	35	10.829	5.055	17	13.412	4.473	1.79*
CM-T	22	9.818	4.982	30	13.033	4.597	2.40*
CSU	23	9.391	4.998	29	13.483	4.231	3.20*
CSC	27	11.111	5.279	25	12.280	4.668	.84
CSR	20	10.300	5.602	32	12.531	4.429	1.60
CS-T	23	9.783	5.205	29	13.172	4.318	2.57*

* $p < .10$

TABLE 7

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF VERBAL LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE RETENTION TEST I

Independent Variable	Group B (Ss < $\bar{x}$) N	Mean	S.D.	Group A (Ss > $\bar{x}$) N	Mean	S.D.	t
CFU	25	10.400	4.865	23	13.913	4.199	2.67*
CFC	27	10.852	4.444	21	13.667	4.983	2.06*
CFR	21	11.095	4.560	27	12.852	5.005	1.25
CF-T	27	10.444	4.003	21	14.190	5.105	2.85*
CMU	22	10.318	4.834	26	13.577	4.411	2.44*
CMC	22	11.091	4.689	26	12.923	4.907	1.32
CMR	33	11.333	4.641	15	13.733	5.035	1.62
CM-T	21	10.476	4.986	27	13.333	4.429	2.10*
CSU	23	10.522	4.461	25	13.520	4.823	2.23*
CSC	25	11.520	4.547	23	12.696	5.182	.84
CSR	18	12.000	4.947	30	12.133	4.869	.09
CS-T	22	11.227	4.587	26	12.808	5.028	1.13

* $p < .10$

TABLE 8

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF VERBAL LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE RETENTION TEST II

Independent Variable	Group B ($Ss < \bar{x}$) N	Mean	S.D.	Group A ($Ss > \bar{x}$) N	Mean	S.D.	t
CFU	24	10.333	5.467	18	12.889	4.391	1.63
CFC	24	10.750	5.067	18	12.333	5.236	.99
CFR	19	11.000	4.509	23	11.783	5.681	.49
CF-T	25	10.640	4.698	17	12.588	5.669	1.21
CMU	19	10.105	4.829	23	12.522	5.230	1.54
CMC	19	9.790	4.602	23	12.783	5.257	1.94*
CMR	30	10.900	4.887	12	12.750	5.723	1.06
CM-T	17	9.824	4.927	25	12.520	5.084	1.71*
CSU	20	10.100	4.767	22	12.636	5.269	1.63
CSC	20	10.400	5.519	22	12.364	4.696	1.25
CSR	18	10.222	4.941	24	12.333	5.198	1.33
CS-T	20	10.350	5.081	22	12.409	5.105	1.31

* $p < .10$

TABLE 9

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF SYMBOLIC LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON THE LEARNING TEST

Independent Variable	Group B (Ss < $\bar{x}$)			Group A (Ss > $\bar{x}$)			t
	N	Mean	S.D.	N	Mean	S.D.	
CFU	35	9.857	5.364	26	11.385	4.281	1.20
CFC	27	9.444	5.228	34	11.353	4.625	1.51
CFR	24	9.125	5.488	37	11.405	4.419	1.79*
CF-T	28	8.786	5.224	33	11.970	4.261	2.62*
CMU	32	9.312	4.734	29	11.828	4.929	2.03*
CMC	27	8.704	4.778	34	11.941	4.671	2.66*
CMR	36	9.056	4.864	25	12.600	4.368	2.92*
CM-T	26	8.038	4.870	35	12.343	4.207	3.69*
CSU	26	9.154	5.416	35	11.514	4.388	1.88*
CSC	32	8.938	4.295	29	12.241	5.118	2.74*
CSR	28	9.179	5.361	33	11.636	4.343	1.98*
CS-T	30	8.800	5.149	31	12.161	4.204	2.80*

* $p < .10$

TABLE 10

MEANS, STANDARD DEVIATIONS AND t-TEST RESULTS OF SYMBOLIC LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON RETENTION TEST I

Independent Variable	Group B (Ss < $\bar{x}$) N	Mean	S.D.	Group A (Ss > $\bar{x}$) N	Mean	S.D.	t
CFU	30	11.467	5.482	24	11.667	5.096	.14
CFC	21	10.381	5.491	33	12.303	5.059	1.32
CFR	21	10.714	5.396	33	12.091	5.192	.94
CF-T	23	10.522	5.186	31	12.323	5.275	1.25
CMU	27	10.778	5.294	27	12.333	5.218	1.09
CMC	23	9.478	4.728	31	13.097	5.179	2.63*
CMR	31	10.355	5.004	23	13.174	5.280	2.00*
CM-T	21	9.048	4.511	33	13.152	5.142	2.99*
CS	24	10.667	5.036	30	12.267	5.420	1.11
CSC	27	11.259	4.720	27	11.852	5.836	.41
CSR	25	10.240	5.206	29	12.690	5.135	1.74*
CS-T	27	10.296	5.312	27	12.815	5.000	1.79*

* $p < .10$

TABLE 11

MEANS, STANDARD DEVIATIONS, AND t-TEST RESULTS OF SYMBOLIC LESSON GROUPS ABOVE OR BELOW THE MEAN FOR EACH INDEPENDENT VARIABLE ON RETENTION TEST II

Independent Variable	Group B (Ss < $\bar{x}$)			Group A (Ss > $\bar{x}$)			t
	N	Mean	S.D.	N	Mean	S.D.	
CFU	26	10.269	4.976	24	11.708	5.034	1.02
CFC	21	9.286	4.828	29	12.172	4.856	2.08*
CFR	20	9.650	4.826	30	11.833	5.011	1.53
CF-T	23	8.826	4.609	27	12.778	4.669	3.00*
CMU	26	9.269	4.618	24	12.792	4.845	2.63*
CMC	20	8.950	4.407	30	12.300	4.998	2.43*
CMR	29	9.552	5.159	21	12.905	4.158	2.45*
CM-T	20	8.550	4.785	30	12.567	4.546	3.00*
CSU	20	10.450	4.925	30	11.300	5.114	.58
CSC	26	10.000	4.445	24	12.000	5.453	1.43
CSR	22	9.136	4.941	28	12.393	4.653	2.39*
CS-T	24	9.417	4.863	26	12.385	4.792	2.17*

* $p < .10$

TABLE 12

SUMMARY OF REGRESSION ANALYSIS ON THE LEARNING TEST

Independent Variable	Figural Lesson		Verbal Lesson		Symbolic Lesson		Intersection of Regression Lines			t values		
	Slope	Intercept	Slope	Intercept	Slope	Intercept	F vs V	F vs S	V vs S	F vs V[a]	F vs S[b]	V vs S[b]
CFU	.12595	11.40769	.46617	6.92516	.26001	7.97057	13.17539#	25.63857	5.07087#	-1.15		.66
CFC	.59659	5.95456	.32505	8.46695	.55172	4.17610	9.25238#	-39.63580	18.92993#	.60		-.76
CFR	.29158	9.22291	.68446	3.05736	.37065	6.23457	15.69321#	37.79358	10.12463#	-1.26*		1.06
CF-T	.22601	4.78949	.29542	1.95683	.24558	2.14538	40.81053#	135.11044	3.78310#	-.53		.38
CMU	.25634	9.40156	.26110	7.87924	.44716	4.17725	319.81323	27.37820#	19.89674#		-.79	-.84
CMC	.61775	-.80826	.48840	.88314	.40345	1.41759	13.07615#	10.38660#	6.29134#	.53	.86	.35
CMR	1.44437	4.60598	1.41450	3.79344	.84074	5.58519	-27.20251	1.62220#	3.12282#		.91	.90
CM-T	.30480	.24882	.24253	1.39406	.28518	-1.83023	18.39149#	-105.96579	75.59882	.48		
CSU	.16659	10.20121	.60047	1.90233	.33491	5.11496	19.12712#	30.21773	12.09757#	-1.92**		1.31*
CSC	1.13701	4.74535	.88403	4.94297	.44490	7.54274	.78117#	4.04183#	5.92027#	.55	1.72**	1.04
CSR	.28508	10.17386	.37132	8.24099	.28718	8.00999	22.41267	1030.84717	-2.75612			
CS-T	.24371	4.91181	.31617	1.14259	.21709	3.40915	52.01794#	-56.44849	22.87604#	-.54		.87

Intersection within range of possible scores on independent variable

* $p < .10$

** $p < .05$

a df = 76

b df = 83

TABLE 13

SUMMARY OF REGRESSION ANALYSIS ON RETENTION TEST I

Independent Variable	Figural Lesson Slope	Figural Lesson Intercept	Verbal Lesson Slope	Verbal Lesson Intercept	Symbolic Lesson Slope	Symbolic Lesson Intercept	Intersection of Regression Lines F vs V	Intersection of Regression Lines F vs S	Intersection of Regression Lines V vs S	t values F vs V[a]	t values F vs S[b]	t values V vs S[b]
CFU	.21051	10.74755	.55905	6.01385	.04969	10.81934	13.58151#	.44640	9.43437#	-1.22		1.63*
CFC	.76736	4.29858	.38313	7.93041	.49829	5.37162	9.45223#	3.98796#	22.21944	1.43*	.93	
CFR	.28492	9.63134	.45962	5.96286	.30195	7.63548	20.99873#	117.19666	10.60836#	-.55		.51
CF-T	.28802	2.89604	.27880	2.55792	.17955	5.02762	-36.67247	19.65132#	24.88362#		.74	.74
CMU	.43271	7.33684	.26557	7.86299	.44087	4.82367	3.14796#	307.98657	17.33781#	.67		-.79
CMC	.60392	-.17693	.36446	3.69078	.56603	-1.81356	16.15179#	-43.19420	27.30733#	.98		-.84
CMR	1.04136	7.23822	1.19289	5.09001	1.05447	4.81050	14.17686	185.19197	-2.01929			
CM-T	.33971	-.87243	.20521	3.03746	.33376	-3.43004	29.06979#	-429.84766	50.31114#	1.06		-1.10
CSU	.09282	11.71023	.27859	7.23118	.27989	6.60364	24.11073#	27.29774#	482.73120	-.78	-.77	
CSC	.85988	7.05189	.70152	6.39829	.12468	10.44651	-4.12730	4.61727#	7.01792#		1.59*	1.32*
CSR	.14352	11.84011	.13225	10.55023	.40638	7.40168	-114.45212	16.88515#	11.48560#		-.86	-.99
CS-T	.15368	8.17850	.15878	6.47282	.19147	4.83542	334.44604	88.46466	50.08871#			-.27

Intersection within range of possible scores on independent variable

* $p < .10$

a df = 76

b df = 83

TABLE 14

SUMMARY OF REGRESSION ANALYSIS ON RETENTION TEST II

Independent Variable	Figural Lesson		Verbal Lesson		Symbolic Lesson		Intersection of Regression Lines			t values		
	Slope	Intercept	Slope	Intercept	Slope	Intercept	F vs V	F vs S	V vs S	F vs V[a]	F vs S[b]	V vs S[b]
CFU	.25779	9.44675	.47585	6.64993	.33631	7.37176	12.82592#	26.42625	5.17293#	-.70		.44
CFC	.84154	2.68810	.33364	8.20520	.53515	4.60932	10.86257#	6.27050#	17.84467#	1.75**	1.06	-.66
CFR	.31735	8.47514	.39511	6.55712	.37813	6.37621	24.66589	34.53323	-10.65431			
CF-T	.32340	.88024	.23955	3.63385	.25812	1.93705	32.83971#	16.18886#	91.37340	.61	.45	
CMU	.52842	5.28995	.12634	9.70201	.44589	4.43011	10.97309#	-10.41850	16.49788#	1.49*		-1.39*
CMC	.57997	-.39637	.23118	6.43119	.50110	-.62145	19.57498#	-2.85381	26.12862#	1.27		-1.07
CMR	1.79481	2.17474	.84952	6.79644	.83827	5.83457	4.88919#	3.82611#	-85.49933	1.17	1.32*	
CM-T	.38764	-3.60815	.12049	6.43004	.30861	-2.63463	37.57509#	12.31836#	48.18556#	1.91**	.58	-1.52**
CSU	.11923	10.53639	.35495	5.75384	.25427	6.71997	20.28911#	28.26140#	9.59605#	-.92	-.55	.45
CSC	.82401	6.55835	.78375	5.54016	.30651	8.79261	-25.29039	4.31741#	6.81512#		1.10	1.08
CSR	.31577	9.45813	.15061	10.15173	.42706	6.88096	4.19956#	23.15724	11.83133#	.50		-.94
CS-T	.20205	5.84813	.19128	5.15764	.20620	4.01421	-64.11218	441.91113	76.63739			

Intersection within range of possible scores on independent variables

* $p < .10$

** $p < .05$

a df = 76

b df = 83